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Letter to the editor regarding Wine et al. (2019): Lake Kinneret and climate change

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In recent years, the Kinneret Lake (Sea of Galilee) has seen a steady decline in its volume, with water level now beneath the precautionary line "red line", below which there is a risk of rapid salinization. A recent article, published in *Science of the Total Environment*, considers the reasons for the rapid drop in mean water level in the lake (Wine et al., 2019). The authors report that it is not climate change but rather excessive water extractions authorized by Israel's Water Authority that constitutes the predominant reason for the low levels of water in the lake. They argue: "*Climatic factors alone are inadequate to explain the record shrinkage of the Sea of Galilee. We found no decreasing trends in in-flow from the headwaters of the Upper Jordan River located primarily in Lebanon. Rather, the decrease in discharge of the Upper Jordan River corresponded to a period of expanding irrigated agriculture, doubling of groundwater pumping rates within the basin, and increasing of the area of standing and impounded waters. While rising temperatures in the basin are statistically significant and may increase evapotranspiration, these temperature changes are too small to explain the magnitude of observed streamflow decreases.*" (Wine et al., 2019, 70).

Unfortunately, the findings of Wine et al. are not based on any actual measurements of inflow into the lake, but rather evaluation of remotely sensed images, assessing a few wells in the upper part of the Jordan River watershed, along with a statistical reconstruction (using the non-parametric Mann Kendall trend test) of natural inter-annual hydrographs. The authors seek to predict what natural flows into the lake might have been in the absence of extensive anthropogenic perturbations. Using such an indirect methodology was justified "since the Israel Water Authority did not make recent water consumption data available for this research." (Wine et al., 2019, 73).

It is unfortunate that the authors choose not to rely on the extensive available empirical data when dismissing the influence of climate change on inflow into the Kinneret. Israel's Water Authority is extremely conscientious about monitoring Israel's scarce water resources and generally makes most of its data available to the public, albeit typically in Hebrew. Measurements over the past forty years in the watershed directly contradict the arguments of Wine, et al., and strongly support the view that it is in fact climate change, and the associated reduced rainfall, that is responsible for the Lake Kinneret's reduced inflow. Kinneret water levels are predominantly driven by rainfall. While there are inter-annual fluctuations, average perennial precipitation measured since 1985 shows a 20% average drop in precipitation in the surrounding basins (Givati and Tal, 2017). Flow in Lake Kinneret's tributaries, including the upper Jordan River, is primarily fed by rains and snowmelt from the Golan Heights. Notwithstanding annual fluctuations, a generally reduced flow has been measured across the Kinneret watershed over the past decade, especially in the Jordan River, where volume has dropped by over 50% since 2004 (Israel Hydrological Service, 2018).

Israeli law is extremely stringent about water extraction and water usage is highly monitored. Over the past forty years, aggregated data of water consumption in the basin indicate that among both municipal and agricultural sources in the Kinneret has generally dropped (Sapir and Sagui, 2014). For instance, extractions, for use by Galilee fish ponds, previously a major water consumer, have essentially been discontinued. Accordingly, during the past decade, total annually water removal averaged around 180 million m^3, while previously, during the 1980s and 1990s, total annual capture could often be as high as 210 million m^3. In short, agricultural allocations have decreased in recent years, but Kinneret Lake levels continue to drop.

In reaching their conclusions, Wine et al., rely on an article by this author (Tal, 2018) that they claim reported a 150 million m^3 $year^{-1}$ increase in water consumption between 1975 and 2016. A closer reading of my article reveals that the statement refers to Israel's general increase in water consumption due to steady population growth. It certainly does not refer to Galilee farmers' water usage and their agricultural needs, which have actually decreased slightly over the past 40 years.

As consumption in the watershed declined, water inflow into the Kinneret lake *should have* increased or at least stayed steady. It did not. Data from the past forty years from Water Authority, indicate that despite occasional high rainfall years, the general trend of inflow into the Kinneret, is dropping. And while measurements of evaporation rates in the Kinneret are inherently imprecise (Assouline and Mahrer, 1993), in general, the positive effect of rising temperatures on evaporation and surface water depletion is well documented (Sereda et al., 2011; Roderick et al., 2014).

It is important that unsubstantiated claims, minimizing the pernicious impact of climate change on the environment be challenged. Given the gravity of the climate crisis, complacency about its potential impact will leave countries unprepared in their adaptation levels and offer a basis for rationalization and elusive policies in mitigation efforts. Our conclusion is that climate change is the predominant cause of the alarming drop in Lake Kinneret water levels, yet another disturbing sign of the consequences of global warming and climatic instability caused by anthropogenic activities.

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